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VARIATION IN THE COMPOSITION OF THE TEA LEAF THROUGHOUT THE SEASON

BY

P. H. Carpenter and C. R. Harler.

Introduction.

It has often been stated that good tea is made in the garden and may be spoilt in the factory. It is, however, easy to over-estimate the natural advantages possessed by a garden or a district and to minimise the good results obtained by careful manufacture. The quality of tea is influenced by the soil, by the *jat* of bush, by the method of cultivation, pruning and plucking, by the weather and by manufacture.

Light leaved bushes give slightly better quality tea than dark leaved. China bushes in Assam generally give poorer teas than either light or dark leaved bushes. Light pruned bushes plucked close and fine give better tea than cut back bushes. Hot steamy weather or hot dry weather are against the manufacture of good tea because the withering conditions are unfavourable.

All the factors mentioned excepting the weather are capable of being influenced. In the factory itself conditions are more easily controlled. In some factories, tea can be improved by increasing the withering space and the number of rollers and driers. It frequently happens that machinery and space are so limited that in order to keep up with the incoming leaf, incompletely withered leaf is rolled or tea is allowed to overferment before it is fired.

Below is given some account of the changes occurring in the composition of the tea leaf throughout the season and an attempt is made to show that factory and not field conditions are largely responsible for the poor teas made during the rains.

Experimental Details.

The leaf from two half-acre blocks of tea in the Tocklai 1914 Clearance was taken for the experiment. One block was composed of Burma and the other of Singlo, light leaved indigenous bushes. Half of each block was skiffed and plucked to the *janam* after

leaving one large leaf at the first plucking. The other half of each block was pruned at 16″ leaving 2 fingers of one-year wood. It was plucked after leaving 6″ new wood, afterwards leaving only the *janam*. All the bushes were plucked every seven days.

Each fortnight the leaf was analysed for tannin, nitrogen, potash, phosphates and lime.

In order fully to appreciate the analyses given below the course of the 1922 season and the crop change should be followed from the chart given in the Quarterly Journal, Part IV, 1922. This chart clearly illustrates the variation shown in the table below :—

TABLE I.

Showing the yield in lbs. each fortnight from Burma and Singlo plots.

Fortnight ending.	Burma skiffed.	Burma cut to 16″.	Singlo skiffed.	Singlo cut to 16″.
May 8th ...	18 lbs.	5 lbs.	11 lbs.	5 lbs.
„ 22nd ...	52 „	46 „	42 „	33 „
June 5th ...	47 „	45 „	47 „	36 „
„ 19th ...	32 „	56 „	14 „	33 „
July 3rd ...	36 „	56 „	35 „	47 „
„ 17th ...	37 „	65 „	44 „	70 „
„ 31st ...	52 „	73 „	44 „	59 „
Aug. 14th ...	50 „	75 „	50 „	75 „
„ 28th ...	52 „	63 „	42 „	63 „
Sept. 11th ...	42 „	74 „	50 „	76 „
„ 25th ...	37 „	50 „	40 „	50 „
Oct. 9th ...	40 „	60 „	50 „	62 „
„ 22nd ...	44 „	44 „	50 „	38 „

It is noticeable that after June 19th the pruned bushes gave the greater yield, for 1922 was a season commencing with a drought and was hence unfavourable for unpruned tea.

The other point to be observed is that after the set back in the crop on about June 19th which is very marked except in the case of the Burma pruned bushes, there is a more or less steady yield till the end of the season.

These two points will be referred to later on.

Changes in Tannin throughout the 1922 Season.

Below is a table showing the variation in the tannin throughout 1922 Season. Values are calculated as percentages on dry leaf :

Table II.

Date.	Burma skiffed.	Burma cut to 16".	Singlo skiffed.	Singlo cut to 16".	Average.
May 8th ...	18·0	18·0	18·4	20·0	18·6
„ 22nd ...	21·5	18·1	24·1	20·3	21·0
June 5th ...	24·5	26·0	26·8	26·7	26·0
„ 19th ...	30·1	30·1	30·2	28·8	29·8
July 3rd ...	24·9	23·6	23·7	25·6	24·5
„ 17th ...	25·9	26·0	24·5	24·0	25·1
„ 31st ...	25·9	27·3	24·5	25·0	25·7
Aug. 14th ...	24·8	25·7	23·9	27·5	25·5
„ 28th ...	22·4	22·5	24·0	22·6	22·9
Sept. 11th ...	18·3	20·3	19·9	21·4	20·0
„ 25th ...	22·6	22·2	22·3	22·9	22·5
Oct. 9th ...	22·4	21·5	23·0	23·2	22·5
„ 23rd ...	22·8	21·2	22·8	21·7	22·4
Nov. 6th ...	23·6	24·7	.....	.....	24·1
„ 20th ...	23·0	23·6	22·9	23·6	23·3
Average ...	23·4	23·4	23·6	23·8	23·6

Considering first the average value for each plucking it is seen that during the earliest part of the season when the bush is flushing vigorously and growth is apt to be rank, the tannin value is low. Towards the end of June the tannin rises to about 30%. This figure is exceptional. Reference to the crop curve for this period shews that the growth had been considerably slowed up and the shoots were exceptionally small. The shortage of stalk at this period was most marked and good teas were made partly because of the fineness of the shoots and high tannin content, no doubt, but also because of the good withering conditions which prevailed.

After the irregularity on June 19th just mentioned, the tannin was fairly constant at about 25% till the end of the season except for a marked depression on September 11th. There was no particular change in the crop at this period. A somewhat similar

depression has been noticed previously and was mentioned in the Quarterly Journal, part III, 1922, page 102. In this particular case a depression occurred on the September 8th plucking for the Burma bushes and later, on October 20th, for the Singlo bushes. No explanation of this depression can at present be given.

Taking now the change in tannin of the individual blocks it is seen that they all vary much in the same way. The pruned bushes appear to start the general increase a little later than the skiffed tea but apart from that there is a remarkable evenness about the results.

It is generally considered that unpruned bushes give better liquoring teas than cut back bushes. In the light of this idea the following tannin values are of interest.

The tannin values for 1921 are worked out from the table given on page 102 of part II of the Quarterly Journal for 1922. In that year the annually pruned bushes were cut to 14″ and the biennially pruned to 10″. In the following year the annually pruned bushes were cut to 16″ and the biennially were skiffed. The 1922 values are the averages from table II above.

TABLE III.

Showing the Tannin Content of Burma and Sinlgo bushes during 1921 and 1922.

Season.	Burma biennial.	Burma annual.	Singlo biennial.	Singlo annual.
1921	20·24% (cut to 10″)	21·42% (cut to 14″)	19·56% (cut to 10″)	22·30% (cut to 14″)
1922	23·4% (skiffed)	23·4% (cut to 16″)	23·8% (skiffed)	23·6% (cut to 16″)

In 1921 the annually pruned bushes, *i.e.*, cut to 14″, are distinctly superior to the biennial, *i.e.*, cut to 10″, in tannin content. In 1922 however the values are practically all the same. It must be remembered that the higher cut bushes, *i.e.* the biennial, were plucked on a long shoot although on two year wood and one leaf was left at the first plucking. These two factors apparently neutralise the beneficial effect of the high pruning. If this is so then

it may be that unpruned or skiffed tea will only give extra good liquors so long as the shoots come fromold wood which is not too long.

The 1921 tannin values are much below those of 1922. The former season was noticeable for poor liquoring teas and the fact that 1921 was a season of little sunshine has been mentioned previously (Quarterly Journal, part IV, 1922) and it was suggested that the tannin content of the tea in that season would show a deficiency. The figures confirm this. The season 1922 had, on the other hand, a sunshine record above the average.

In addition, of course, the bushes are getting more mature. In 1922 they were 9 years old, from seed.

Variation in Nitrogen Content throughout the season.

The nitrogen content of the tea leaf varies considerably from plucking to plucking, changing from 4·5 to 5·5% at the extremes. There is, however, no regular gradation in the change.

Table IV.

Showing the change in Nitrogen Content throughout the Season 1922.

Plucking date.	Burma skiffed.	Burma cut to 16″.	Singlo skiffed.	Singlo cut to 16″.
May 8th ...	5·21	5·05	5·51	5·40
„ 22nd ...	5·16	5·60	5·91	5·50
June 5th ...	5·44	5·15	5·56	5·37
„ 19th ...	4·71	4·54	4·81	4·53
July 3rd ...	4·76	4·84	5·09	5·07
„ 17th ...	4·68	4·94	4·54	4·55
„ 31st ...	5·34	4·96	5·12	5·20
Aug. 14th ...	5·08	4·47	4·78	4·42
„ 28th ...	4·94	4·61	5·12	5·03
Sept. 11th ...	4·50	4·63	4·55	4·71
„ 25th ...	4·70	4·66	4·73	4·75
Oct. 9th ...	5·11	4·89	4·62	5·00
„ 23rd ...	4.80	4·97	4·81	5·02
Average ...	4·96	4·87	5·01	4·97

The nitrogen content is generally highest at the beginning of the season and it shows its first serious decrease on June 19th

when the crop also decreased and the tannin increased. From this date the variation shows no regularity in either direction.

The early season's growth is longer than that later on and this may possibly account for the high nitrogen values at this period. It has been shown (Quarterly Journal, part IV, 1922) that the nitrogen content of the tea leaf can be increased by heavy nitrogenous manuring, but it is unlikely that the quantity of manure added would be sufficient to make this noticeable in this case. Neither do the above figures indicate that the nitrogen content of the leaf increases as the tannin content diminishes.

The average values are remarkably even.

VARIATION IN THE POTASH CONTENT THROUGHOUT THE SEASON.

The potash content varies between 2 and about 2·5% but the change is not so sudden or irregular as that shown by nitrogen. Below are shown the potash values calculated as percentages on the dry leaf :—

TABLE V.

Date.	Burma skiffed.	Burma cut to 16″.	Singlo skiffed.	Singlo cut to 16″.
May 8th ...	2·37	2·20	2·35	2·25
„ 22nd ...	2·26	2·16	2·20	2·54
June 5th ...	2·10	2·14	2·19	2·23
„ 19th ...	2·11	2·08	2·03	2·04
July 3rd ...	2·13	2·11	2·16	2·21
„ 17th ...	2·17	2·15	2·32	2·34
„ 31st ...	2·35	2·19	2·17	2·26
Aug. 14th ...	2·50	2·29	2·24	2·29
„ 28th ...	2·36	2·33	2·40	2·37
Sep. 11th ...	2·50	2·26	2·46	2·34
„ 25th ...	2·29	2·39	2·31	2·28
Oct. 9th ...	2·85	2·77	2·63	2·47
„ 23rd ...	2·51	2·40	2·61	2·48
Average ...	2·50	2·27	2·47	2·32

Apart from one or two irregularities there is a steadiness which is not present either with nitrogen or tannin. About June 19th there is a slight but well defined decrease corresponding with

the crop decrease. Towards the end of the season when the crop is falling off there is an increase.

Previous work (Quarterly Journal, part IV, 1922) has shown that, taken over the whole season for several seasons, the potash varies inversely as the nitrogen.

The average potash values for skiffed tea are considerably higher than those for the pruned tea. Analysis of individual figures, however, shows that only during the first plucking or two and from about half way through the season are the potash values of the skiffed bushes much above those of the pruned bushes. The period of crop depression and the ultimate recovery coincides with poorness in potash content of the leaf.

The average value of all the pluckings is 2·39 %, which is considerably below the values given in previous years by other Tocklai plots. These values are discussed later.

Variation in Phosphatic Content throughout the Season.

Below are shown the phosphatic values for the 1922 pluckings. Values are calculated as percentages of phosphoric acid on dry leaf:—

Table VI.

Plucking date.	Burma Skiffed.	Burma cut to 16″.	Singlo skiffed.	Singlo cut to 16″.
May. 8th ...	0·93	0·92	0·97	0·89
,, 22nd ...	0·92	1·01	0·93	0·91
June. 5th ...	0·89	0·85	0·90	0·82
,, 19th ...	0·83	0·80	0·75	0·76
July. 3rd ...	0·88	0·85	0·85	0·84
,, 17th ...	0·81	0·85	0·80	0·81
,, 31st ...	0·93	0·87	0·88	0 91
Aug. 14th ...	0·97	0·86	0·89	0·92
,, 28th ...	0·81	0·91	0·91	0·91
Sept. 11th ...	0·89	0·85	0·85	0·89
,, 25th ...	0·90	0·86	0·84	0·89
Oct. 9th ...	1·03	0·96	0·87	0·95
,, 23rd ...	0·91	0·93	0 91	0·95
Average ...	0·90	0·89	0·87	0·90

The phosphatic values are very steady and bear out the experience of the past that the phosphates in the leaf do not appreciably change, even with manuring. On some gardens, quality has been improved by phosphatic manuring. This improvement is probably due to a steadying up in the rate of growth of the leaf.

The average nitrogen, potash and phosphate values for the season 1922 may be compared with those of previous years given by another plot at Tocklai. (Quarterly Journal, part IV, p. 141, 1922).

TABLE VII.

Year.	1919.	1920.	1921.	1922.
Nitrogen % ...	5·05	5·57	5·23	4·95
Potash % ...	2·63	2·53	2·81	2·39
Phosphate % ...	0·90	0·90	0·94	0·89

The results of 1919, 1920 and 1921 are from bushes which were only lightly purned each year.

VARIATION IN LIME CONTENT THROUGHOUT THE SEASON.

The values below show the Variation in Lime :—

TABLE VIII.

Plucking Date.	Burma skiffed.	Burma cut to 16".	Singlo skiffed.	Singlo cut to 16".
May 8th ...	0·60	0·53	0·49	0·55
,, 22nd ...	0·46	0·47	0·39	0·58
June 5th ...	0·50	0·56	0·49	0·53
,, 19th ...	0·51	0·49	0·53	0·51
July 3rd ...	0·50	0·57	0·59	0·49
,, 17th ...	0·63	0·55	0·67	0·63
,, 31st ...	0·60	0·62	0·59	0·55
Aug. 14th ...	0·68	0·75	0·58	0·55
,, 28th ...	0·59	0·65	0·53	0·56
Sep. 11th ...	0·58	0·62	0·59	0·44
,, 25th ...	0·46	0·58	0·46	0·42
Oct. 9th ...	0·71	0·78	0·60	0·49
,, 23rd ...	0·60	0·77	0·62	0·71
Average ...	0·57	0·61	0·65	0·54

The results are of the same order as shown by other analyses.

Conclusions.

There is no definite tannin increase in the tea leaf at the end of the season when good teas are made. Although about June 19th, 1922, the tannin increased and good quality teas were made, the weather was such that a good wither was possible.

During the earlier part of the year nitrogen varies at the rate of growth. Later on, however, there is no such correlation.

The potash slightly increases towards the end of the season. As with the tannin and nitrogen the potash was influenced by the crop depression in June.

The phosphates are fairly steady throughout the season.

Except with the potash value there is no definite rise or fall at the end of the season in the other constituents which were estimated. It appears that climate is a prominent feature in determining quality in tea, for unless the atmospheric conditions are such that good manufacturing conditions are possible, good tea cannot be made.

PART II.

Variation in Composition of Bud, Leaves and Stalk of the Tea Bush.

In a previous article (Quarterly Journal, part III, 1922) it was shown that the tannin content of the bud and first leaf was about the same and that the leaves gradually decrease in their tannin content the lower they are down the stalk. These figures have been calculated on to the total shoot and are compared with the 1922 shoots in table III on page 4 above.

The same shoot parts were analysed for potash, phosphates, nitrogen, lime and ash content. In order to make a sufficient sample for analysis the whole month's sample of leaf from bushes

cut to 10″ and 14″ had to be mixed. The Burma and Singlo samples were analysed separately. The table below is typical of all the results, which are given later in detail :—

LEAF PLUCKED IN AUGUST 1921

Singlo leaf.

	Ash %.	N. %.	Potash %.	Phosphate %	Lime %.
Bud ...	5·08	5·25	2·22	1·08	0·27
No. 1 leaf ...	5·67	4·82	2·47	0·93	0·64
No. 2 leaf ...	6·76	4·89	2·77	0·88	0·70
Stalk ...	7·90	4·69	3·43	0·92	0·80
Calculated on shoot ...	6·58	4·93	2·81	0·84	0·62

The ash in the stalk is always much greater than that in the leaves and the bud. A similar gradation is observed in the lime values.

The phosphate values are all more or less alike and constant throughout the season. The bud is usually richest in phosphates. In potash, the stalk is richest, this being expected for the more woody the material the greater the potash value.

With nitrogen the bud is richest, and the stalk and leaves are very similar in nitrogen content.

The values calculated for the shoot are from the shoot constitution as follows :—

Bud ...	...	14	per cent. of shoot.
first leaf ...	...	21	„ „
second leaf ...	...	38	„ „
stalk ...	...	27	„ „

which represent the average composition of shoots plucked during the 1921 season.

The full results and averages are shown below :—

Nitrogen. Burma bushes.

Plucking.	Bud.	No. 1 leaf.	No. 2 leaf.	Stalk.	Calculated on shoot
May 1921 ...	6·04	5·28	4·79	4·83	5·13
June ,, ...	5·75	5·33	5·27	5·04	5·29
July ,, ...	5·93	5·51	4·45	4·85	4·98
Aug. ,, ...	5·88	5·38	5·06	4·80	5·19
Sept. ,, ...	5·75	4·99	4·67	4·47	4.83
Oct. ,, ...	5·72	5·02	4·78	4·38	4·86
Average ...	5·85	5·25	4·84	4·73	.....

Calculated on shoot for whole year.

Nitrogen = 5·06 %.

Nitrogen. Singlo bushes.

Plucking.	Bud.	No. 1 leaf.	No. 2 leaf.	Stalk.	Calculated on shoot.
May 1921 ...	5·98	5·57	4·76	4·21	4·96
June ,, ...	5·80	5·11	5·33	4·97	5·26
Aug. ,, ...	5·25	4·82	4·89	4·69	4·88
Sept. ,, ...	5·77	4·88	4·83	4·52	4·99
Oct. ,, ...	5·76	5·16	4·59	4·51	4·85
Average ...	5·71	5·11	4·88	4·58	.....

Calculated on shoot for whole year.

Nitrogen = 4·97 %.

Potash. Burma bushes.

Plucking.	Bud	No. 1 leaf.	No. 2 leaf.	Stalk.	Calculated on shoot.
May 1921 ...	.....	2·21	2·46	2·88	.....
June „ ...	2·11	2·26	2·35	2·98	2·46
July „ ...	.....	2·30	2·21	2·90	.....
Aug. „ ...	2·37	2·53	2·64	3·37	2·77
Sept. „ ...	.....	2·46	2·45	3·27	.....
Oct. „ ...	.....	2·62	2·69	.....	.....
Average ...	2·24	2·40	2·47	3·08	.....

Calculated on shoot for whole year.

Potash = 2·59 %.

Potash. Singlo bushes.

Plucking.	Bud.	No. 1 leaf.	No. 2 leaf.	Stalk.	Calculated on shoot.
May 1921 ...	.....	2·35	2·42	3·25	.....
June „ ...	2·28	2·39	2·47	3·02	2·58
Aug. „ ...	2·22	2·47	2·77	3·43	2·82
Sept. „ ...	.....	2·58	2·81	3·55	.....
Oct. „ ...	2·32	2·62	2·73	3·40	2·83
Average ...	2·27	2·48	2·64	3·33	.....

Calculated on shoot for whole year.

Potash = 2·67 %.

Phosphates. Burma bushes.

Plucking.	Bud.	No. 1 leaf.	No. 2 leaf.	Stalk.	Calculated on shoot.
May 1921 ...	.....	1·00	0·87	0·88	.....
June „ ...	1·02	0·84	0·75	0·83	0·83
July „ ...	.....	0·90	0·75	0·86	.....
Aug. „ ...	1·21	1·04	0·91	0·93	0·98
Sept. „ ...	.....	0·88	0·77	0·90	.....
Oct. „ ...	.....	0·87	0·76	.....	.....
Average ...	1·11	0·92	0·80	0·88	.....

Calculated on shoot for whole year.

Phosphates = 0·89 %.

Phosphates. Singlo bushes.

Plucking.	Bud.	No. 1 leaf.	No. 2 leaf.	Stalk.	Calculated on shoot.
May 1921 ...	.....	1·00	0·81	0·95	.....
June „ ...	1·13	0·77	0·85	0·86	0·89
Aug. „ ...	1·08	0·93	0·88	0·92	0·93
Sept. „ ...	.....	0·95	0·80	0·95	.....
Oct. „ ...	1·07	0·93	0·75	0·84	0·86
Average ...	1·09	0·92	0·82	0·90	.....

Calculated on shoot for whole year.

Phosphates = 0·89 %.

Lime. Burma bushes.

Plucking.	Bud.	No. 1 leaf.	No. 2 leaf.	Stalk.	Calculated on shoot.
June 1921 ...	0·29	0·57	0·71	0·66	0·64
July „ ...	.....	0·41	0·66	0·64	.....
Aug. „ ...	0·30	0·53	0·78	0·83	0·67
Sept. „ ..	... .	0·49	0·73	0·76	.....
Oct. „ ..	.....	0·61	0·97	.....	.....
Nov. „ ...	0·40	0·31	0·81	.....	.....
Average ...	0·33	0·49	0·78	0·72	.....

Calculated on shoot for whole year.

Lime = 0·66 %.

Lime. Singlo bushes.

Plucking.	Bud.	No. 1 leaf.	No. 2 leaf.	Stalk.	Calculated on shoot.
May 1921 ...	.....	0·48	0·64	0·65	.....
June „ ...	0·29	0·59	0·54	0·74	0·57
Aug. „ ...	0·27	0·46	0·70	0·80	0·62
Sept. „ ...	.....	0·49	0·66	0·82	... ..
Oct. „ ...	0·26	0·43	0·68	0·67	0 57
Average ...	0·27	0·49	0·64	0·74	.....

Calculated on shoot for whole year.

Lime = 0·52 %.

Summarising we get the following values from the 1921 divided shoots. For comparison the 1922 values averaged for both cut back and unpruned, obtained from the whole shoots, are shown :—

Season.	Nitrogen.		Potash.		Phosphate.		Lime.	
	Burma.	Singlo.	Burma.	Singlo.	Burma.	Singlo.	Burma.	Singlo.
1921	5·06	4·97	2·59	2·67	0·89	0·89	0·66	0·59
1922...	4·92	4·99	2·39	2·40	0·90	0·89	0·59	0·59

The values discussed in this part of the paper have little bearing on the main question. In addition figures showing the N. P. and K. content of bushes in 1921 are available, values which were estimated on the whole shoot. The fact that the above values were calculated by a roundabout method on a shoot percentage-composition throughout the season makes individual values rather unreliable, for it is known that the percentage of bud, stalk, etc., in the shoot varies somewhat from plucking to plucking.

The values calculated on the total season's figures are probably reliable but as mentioned above, other figures are available for 1921.

The variation from plucking to plucking can only be calculated for each month in the case of the nitrogen. Since all the leaf for the month had to be mixed in order to make a large enough sample, a correlation between crop and nitrogen cannot be made.

The information given by the first table in part II is the most useful and definite information obtainable from this branch of the work.

A FIRST AID SET FOR DISEASED TEA

BY

A. C. TUNSTALL, B.SC.

In the last Quarterly Journal the emergency treatment of disease was discussed. Treatment cannot be carried out immediately if apparatus and materials are not ready on the spot. It is obviously of the utmost importance that the necessary apparatus and materials should be available on every garden, not only for the safety of the garden itself, but as a safeguard to the whole industry. It is quite within the bounds of possibility for a new disease to attack any garden suddenly and unless checked at once spread all over a district in a very short time. Take the case of Blister blight in Darjeeling. This disease in the course of two years attacked every garden in the district. If an adequate system of blight control had been in working order when the disease first appeared it would have been possible to restrict it to a few gardens and ultimately to eradicate it. When a disease of this nature has once become general it is practically impossible to eradicate it. If an outbreak of disease is treated at the outset the cost is not very great. The same treatment on a larger scale, however, would probably be out of the question.

An ordinary spraying machine can, if the work be properly organised, spray an acre of tea per day. Allowing for contingencies such as rain during the monsoon period, etc., it is only safe to estimate half an acre per day. The chances are that at least an acre of tea will be infected before an outbreak is noticed and it is necessary not only to spray that acre but also a considerable margin of the tea round it, say, 3 or 4 acres in all. There should be sufficient machinery to allow this area to be sprayed in one day. It is, therefore, necessary to have at least half a dozen sprayers in any garden. In the case of large gardens it is quite

likely that more than one outbreak would occur at the same time and a larger number of sprayers would be necessary. One sprayer per 100 acres with the above mentioned minimum should be kept in perfect order on every garden. Sprayers have washers, etc., which dry up and become useless and it is therefore necessary also to have in stock a complete set of spare washers and rubber tubes for each sprayer. Nozzles also give unexpected trouble and a reserve nozzle also should be kept for each sprayer. A few tools which should include wire pliers, screw-drivers and wrenches should also be kept with the spares. All this apparatus must be stored in a convenient manner. The most satisfactory arrangement for gardens in the plains is to have the whole outfit fitted on to a hand cart. The spares and tools should be in a box made with compartments to fit the various items. In such a case it is possible to see at a glance whether everything is there. This box should be fixed to the cart and provided with a lock.

In addition to the spraying machines and their accessories receptacles for spraying fluids are also necessary. These need not be of any special kind, but 40 gallon barrels for diluted solutions and kerosine tins for carrying the solution to the sprayers are very satisfactory. One barrel and two kerosine tins to each sprayer are desirable. These receptacles should all be painted the same colour and should be kept specially for use with the sprayers. Red is a good colour as it is so easily seen against the green of the tea and tins are less likely to be lost sight of in consequence. With a pair of wheels and a little ingenuity it is possible to make a hand cart which will pick up and set down barrels. This would be found very useful Bullock carts for this purpose are not very economical as men have to accompany them to fill and load or unload the barrels.

Next is the question of spray fluids. It is rarely possible to deal satisfactorily with an outbreak with one application of fluid. It is usually necessary to protect the plants from new infection for at least a week and there is always a chance of new outbreak following the first one. As a general rule it takes three weeks or a month to get supplies from Calcutta. Sufficient

materials should be kept in stock to enable all the sprayers to be kept at work until fresh supplies arrive. One sprayer can distribute about 150 gallons of spray fluid a day. It would therefore be necessary to keep sufficient materials to prepare 150 × 30 gallons of solution per sprayer. The most satisfactory emergency spray fluid for use in tea gardens is Lime-sulphur solution. It is useful for some insect pests as well as all fungus diseases. A barrel of concentrated solution should be kept in stock and a sufficient quantity of sulphur and quicklime. The quicklime should be stored in sealed tins. The materials for making other fluids may of course be stocked if preferred.

The stock solution should be prepared carefully and stored still more carefully, taking great care to see that the surface is covered with a film of oil. It is well to use a closed oil barrel and draw off the solution through a tap at the bottom thus leaving the film of oil intact at the top. The barrel of stock solution will enable treatment to be undertaken at once and will keep things going until new stock solution is prepared from the materials in stock.

To summarise : the minimum amount of apparatus and material to be kept in stock on every garden should be—

6 sprayers complete with nozzles.
6 sets of spare parts.
6 spare nozzles.
1 set of tools.
6 40 gallon barrels.
12 kerosine tins fitted with wooden handles and painted.
1 hand cart fitted to carry sprayers and spares.
1 hand cart to transport barrels.

Sufficient materials to prepare 27,000 gallons (150 × 30 × 6) of solution—

Quicklime in tins ...	... 13½ mds.
Sulphur ...	... 15 „

For every hundred acres above 600 there should be in addition—

1 sprayer complete.
1 set of spares.
1 spare nozzle.
1 barrel.
2 kerosine tins.

Sufficient materials to prepare 4,500 (150 × 30) gallons of solution—

i.e., Quicklime in tins ... 180 lbs.
Sulphur ... ... 202½ „

All these sprayers, accessories and materials should be held in reserve for emergency use only. They should not be used for routine work at all any more than the fire buckets in the factory should be so used. For the routine work of spraying other sprayers and materials should be used.

SOIL SURVEY NOTES

The Darrang District

H. R. Cooper and C. R. Harler

PART I

Introduction

Ages ago the Assam Valley probably formed part of an inland sea which stretched from the Naga Hills through Central Asia to the Caspean Sea and then on the Mediterranean. When the Himalayan upheaval took place, geologically speaking, recently, the end of the sea which we now call the Brahmaputra Valley was cut off from the rest. To the north of the Himalayas, which is now known as the Gobi plateau, the sea gradually dried up and now all that remains is a series of lakes which are still drying. To the south of the Himalayas the sea broke through somewhere in the vicinity of Gauhati and the valley gradually drained.

The northern slopes of the Himalayas drain into the Sanpo, which breaks through the mountains at the extreme end of the Himalayan uplift and flows generally westward through Assam where it is known as the Brahmaputra.

It is supposed that when the Himalayas rose, the bed of the sea was partly dragged up with it at the edge of the disturbed area and the red soil which crops out at the foothills may be part of the old sea-bed. It is also supposed that the shock of upheaval disturbed the sea-bed so that it rose and fell in gentle undulations. It is possible that where the red soil now appears are the tops of some of the higher undulations.

With time, the Brahmaputra and its tributaries brought down sand and silt and filled the valley till now between the Naga Hills and the Himalayas there is plain gently sloping to the river and undisturbed but for the occasional appearance of banks of red soil.

BHUTAN
AKHAS
Bhowbli R.
Kerkeria
Orangajuli
Bhutiachang
Hattigor
Dimakusi
Borengajuli
Nagrijuli
Attareekhat
Paniri
Bhergaon
Tangla
Gohain Kamal Ali Bund Road
E.B.S.Ry
Kaligaon
Bongong
Ronthali
KAMRUP
MANGALDAI
DARRANG
Mangaldai
Bungalagor
Jia Bar Ni.
A.B.Ry
GAUHATI
Dhunsiri
Rota
Kopati
Mazbat
Jikribari
TEZPUR
Tarajuli
Kolony
Bhuragaon
Ghoirali
Bamgaon
Bindukuri
Solabari
Katalguri
T.B.R.
Dekajuli
Singri GT
Tezpur
BRAHMAPUTRA
RIVER
NOWGONG

The district of Darrang is a strip of land lying between the Brahmaputra and the Himalayas. At the eastern end it is only about 12 miles wide, but at the western or Mangaldai end it is almost 50 miles wide. At the Boroi or narrow end of the district the soil was probably all laid down by the Brahmaputra which, until recently, must have flowed right up to the hills. In Mangaldai the soil in the southern area came from the Brahmaputra, whilst that in the north came from the Himalayas in the immediate vicinity.

The soils of the Darrang district may be divided into three groups :—

(*a*) Those soils laid down by the Brahmaputra. They are usually sandy soils, poor in plant food.

(*b*) Those deposited from the adjacent hills. They are usually rich loams on rising land which is liable to drought.

(*c*) The older red soils, such as occur in Tezpur and Bishnath.

The sketch map accompanying this account of the Darrang soils shows roughly where each of these groups is found. The location of the groups is not by any means complete, for undoubtedly a bed of rich soils similar to those occurring in Mangaldai is to be found in many places along the foothills. It is also practically certain that outcrops of red soil, such as occur at Kerkeria and behind Singli, are quite common, and even another bank similar to the Tezpur Bank may lie hidden in the jungle to the north of the Tezpur subdivision.

PART II—MANGALDAI

In the Mangaldai district the old red soil has been found only at Kerkeria, which is definitely on the lowest foothills, about 1,000 feet high. The red soil differs from that commonly found in the Dooars, in that fine silt forms about 40% of the soil. The two samples of which analyses are available are of the 4. 5. 3. 1. 2 and 4, 2, 3, 5, 1 types, respectively.

South of the hills the majority of the better gardens of the district lie on more recent sedimentary soil on a marked slope from 650 feet, just north of Orangajuli, to 350 feet, just south of Dimakusi. This strip of land is about six miles broad.

Below this 350 feet contour line there is a marked decrease in slope, the land only falling 100 feet in the next six miles.

A glance at the accompanying sketch map shows that the bigger rivers are running practically straight from north to south as far as this line, while below it their courses become serpentine, as is usually seen on land of small slope. Small streams arising in the hills disappear into the earth before reaching the tea-garden area, and appear again a little above the 350 feet level. The critical line, where this happens, is pretty well marked by trees.

Above the line the cold weather water-table is deep, droughts are felt, and the natural jungle is mainly grass with Khoira trees.

The subsoils are generally coarsely sandy and often stony; but this subsoil is overlaid by deposits, often deep, of very rich soil, containing significant quantities of clay. Clay can not be deposited in any quantity from fast running water. The presence of the clay therefore and the richness of the soil, indicates that these soils have not in general been deposited from rivers; but rather from slow running sheets of water carrying good surface soil from the hills. This water, when held up by the dense high grass, deposited the whole of its silt.

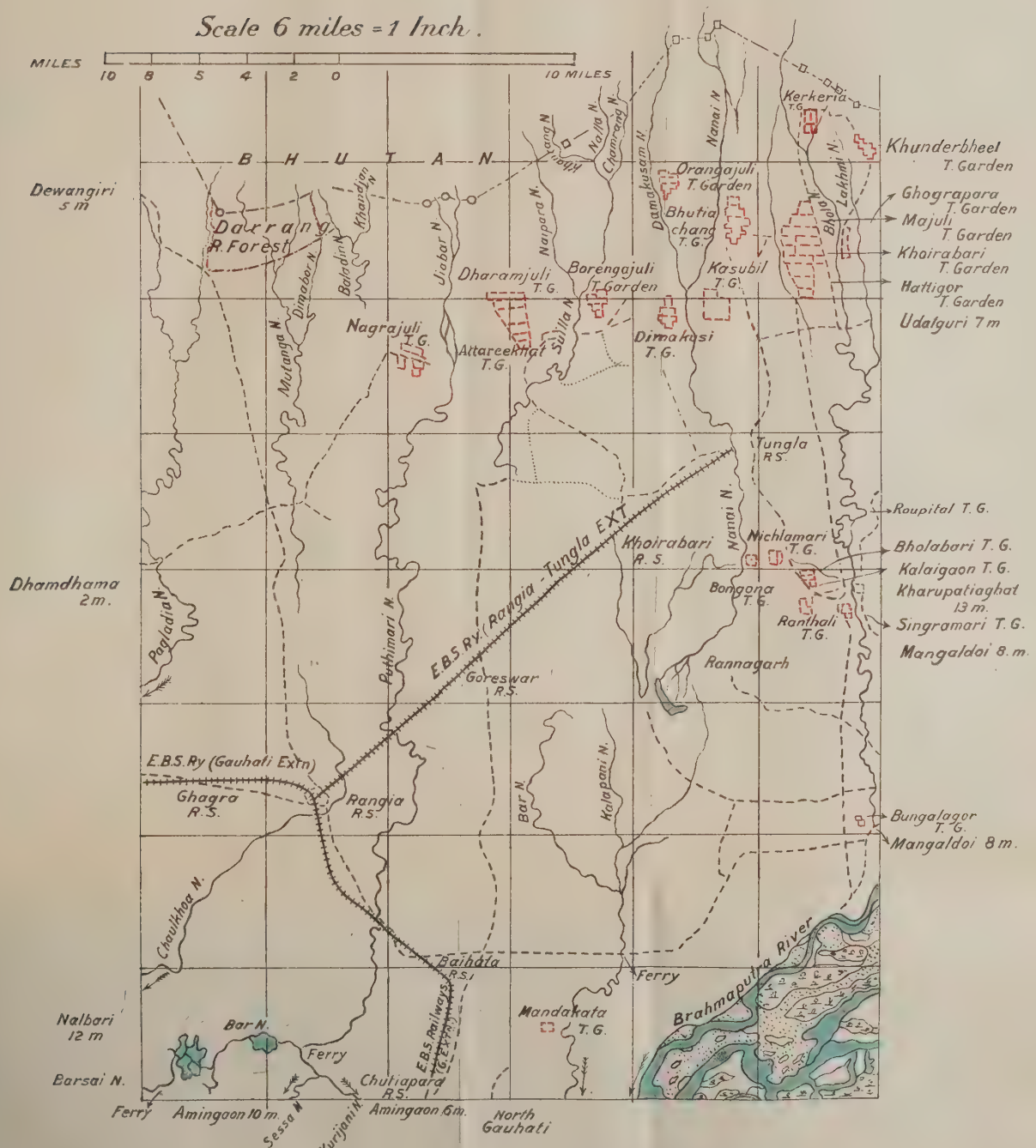
The depth of soil is nearly always greater in the hollow places.

The unplanted areas still remain water-logged in the rains, in spite of the slope; and sheets, rather than streams, of flood water still occasionally wash over some of the gardens.

There are areas of sandy soil brought down by faster running streams which have broken through, all over the district; but the typical soil of the upper Mangaldai bed is a medium loam not containing very much coarse sand.

This bed is an exception to the general rule that grass land is poorer than tree jungle land. The apparent reason is that the

SKETCH MAP
OF THE
MANGALDAI TEA DISTRICT.



REFERENCES.

Roads
Rivers
Railways
T. Gardens
Boundary

T. E. S.
JUNE 1917.

BENGAL ART STUDIO, 1, SIRCAR LANE.

SOIL SURVEY NOTES

DARRANG

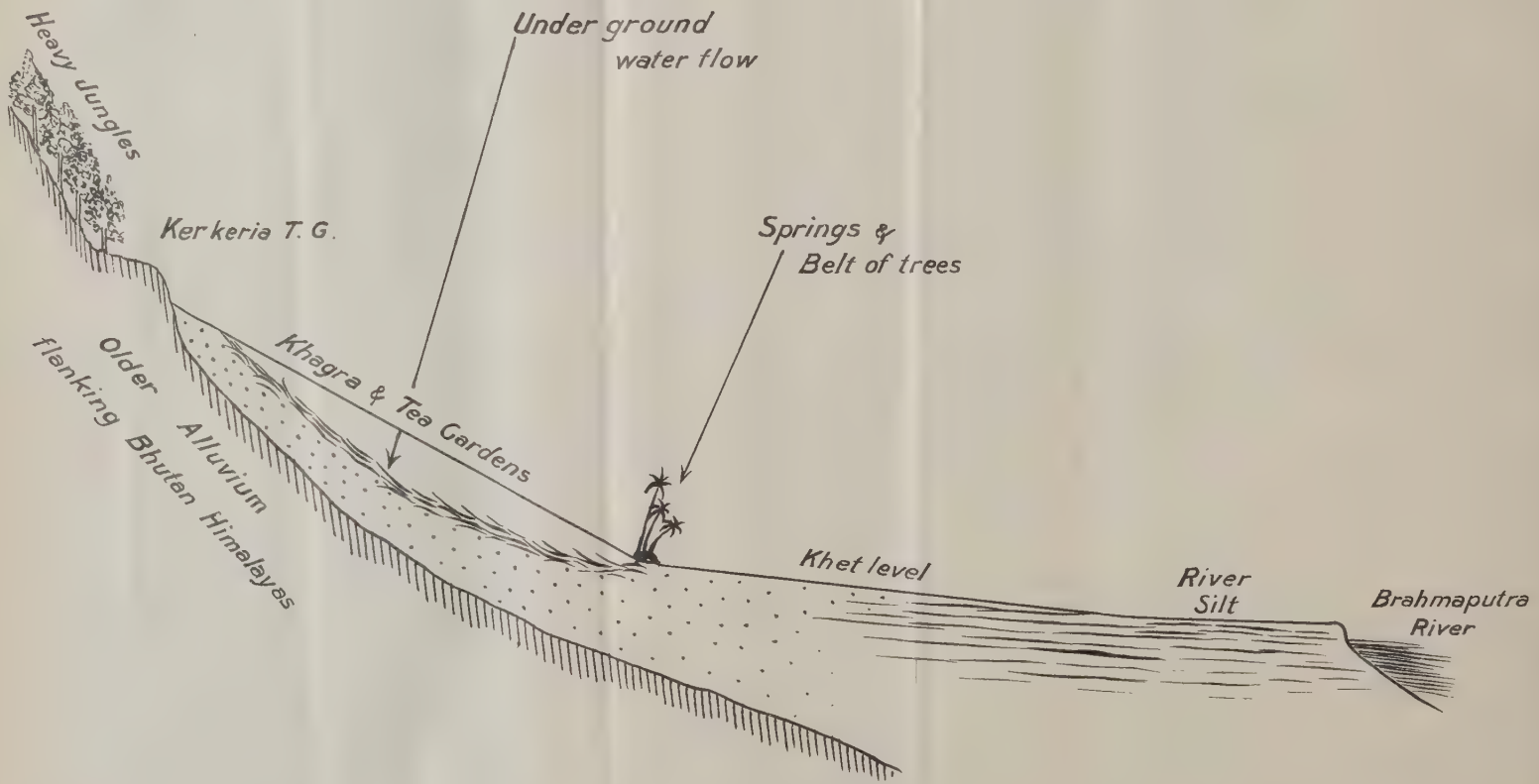


Diagram I

Illustrating the Mangaldai Bed.

B.A.S. & PTG LTD., CAL.

soil was washed into its present position ready-made, and did not have to accumulate its fertility from jungle residues over a long period of time.

South of the critical line, the land is mainly under rice; but several tea gardens have been planted, mainly on patches rather higher than the surroundingly rice land. In these soils the absence of coarse sand is nearly always a feature.

Coarse sand would be expected to be dropped as water slowed up before reaching the lower land. It is however rather unexpected to find the soil of the lower land poorer in clay than the higher land.

It seems probable that the later wash of surface soil from the hills was effectively filtered by the grass jungle and did not reach the lower land. The low land also would be more subject to floods of river water carrying only small percentages of surface soil.

Deposits from the Brahmaputra are usually light soils containing much coarse sand.

The dark-grey soils of the lower Mangaldai bed have nothing in common with Brahmaputra deposits of Bishnauth, but are closely related to the soils of the Upper Mangaldai bed. With the difference indicated above, therefore, the Upper and Lower Mangaldai beds probably originated in the same way, from the hills due north.

Farther south, near that river, soils apparently of Brahmaputra origin are to be seen, but unfortunately no analyses are available.

The lie of these lands is illustrated in the diagram facing this page.

Soils of the Upper Mangaldai Bed.

The physical types found are :—

Kerkeria— 2, 1, 4, 5, 3

Koonderbheel— 2, 1, 4, 5, 3 and 2, 1, 4, 3, 5

The above are sandy banks near the hills.

Orangajuli—

Silt loam types :—	2, 4, 3, 5, 1 (3 samples)
Medium loam type.—	2, 4, 5, 3, 1
Sandy type.—	2, 1, 3, 4, 5

Bhooteachang—

Silt loam types	4, 3, 2, 1, 5 (2 samples)
	4, 3, 2, 5, 1 (2 „)
	4, 3, 2, 1, 5; 2, 4, 3, 1, 5
	2, 3, 4, 1, 5
Sandy type	2, 1, 3, 4, 5; 2, 1, 4, 3, 5

Ghagrapara—

Silt loam types	4, 2, 3, 5, 1
Sandy type	1, 2, 4, 3, 5

Hattigor is apparently very similar to above, but no analyses are available.

The above are gardens well above the critical line. While very much resembling the soils of the more southerly gardens, they do generally contain less clay. On all these the natural drainage due to the bank, and to the pervious subsoil is almost perfect.

Drainage may assist in certain cases, where it would probably best take the form of occasional deep contour drains, the purpose of which is to tap the water from the pervious subsoils, and thus prevent excessive seepage.

The pervious subsoils act as splendid natural under-drainage, and should in general render subsidiary drains unnecessary.

The gardens mentioned below come down very close to the critical line, where the subsoil water is higher. Here artificial drainage has been used extensively of late years, and has undoubtedly proved beneficial. Here too the deep contour type of drain is probably the most efficient generally.

Among the more southerly gardens of the bank the following physical types of soil occur :—

Attareekhat—		
	Medium loam	3, 2, 5, 4, 1; 2, 5, 3, 4, 1; 2, 3, 5, 1, 2.
	Sandy type	2, 1, 3, 5, 4.
Borengajuli—		
	Silt loam	3, 2, 4, 5, 1.
	Medium loam	3, 4, 5, 2, 1; 3, 2, 5, 4, 1.
Dimakusi—		
	Silt loam	2, 3, 4, 5, 1 ; (2 examples.)
		2, 4, 3, 5, 1 ; (2 examples.)
	Medium loam	3, 4, 5, 2, 1 ; (1 example.)
		3, 2, 5, 4, 1 ; (2 examples.)
		2, 3, 5, 4, 1 ; (2 examples.)
Paneery—		
	Medium loam	4, 3, 5, 2, 1.
	Sandy loam	2, 1, 5, 3, 4.
	Sandy type	2, 3, 1, 4, 5.

As in the Daina-Toorsa district of the Dooars (which this district resembles in many respects), there is very great variation in soil types within comparatively small areas.

Yet with the exception of a few sandy patches, the soils of the bank have very much in common.

An examination of the list of physical types given above shows that the commonest are the silt loam types which predominate in the lower parts of the Daina-Toorsa district of the Dooars. As in that district, these types commonly contain significant quantities of clay, although clay forms only the fourth largest fraction, while the smallest fraction (generally coarse sand) averages about 10%. Except on the sandy patches, the types of soil other than "silt loams," are all closely related types, being silt loams where clay has come up into third place, displacing fine sand, silt, or fine silt.

For example: the medium loam type 3, 2, 5, 4, 1 at Borengajuli is thus closely related to the "silt loam" type 3, 2, 4, 5, 1

on the same garden. Similarly are related the 2, 3, 5, 4, 1 and 2, 3, 4, 5, 1 at Dimakusi; also the 2, 4, 5, 3, 1 and 2, 4, 3, 5, 1 at Orangajuli.

The average soils are therefore evenly graded soils, containing significant quantities of clay, which are capable of packing very close and becoming hard.

In this case, however, they generally contain good proportions of sand, and, above all, are accompanied by high percentages of organic matter. They therefore behave as fine free-working soils, easily penetrated by roots, and, with its fine natural advantages with regard to drainage, the Upper Mangaldai bed forms one of the very finest blocks of soil for tea.

The climate tends towards droughts in the early part of the year, particularly on the higher parts of the bank, where not only is the soil water lower, but the soil also lighter. Yet the average medium soil is well fitted to resist drought, particularly when organic matter is high; and in general, serious damage only occurs in places where the stony or coarse sandy subsoils come close to the surface.

These soils containing fair clay and high organic matter do not readily change their nature. They should retain their natural fertility well, but do not easily respond to manures.

As will be seen from examination of the first column of the Table of Analyses the average soil is chemically very rich. Effective manuring is therefore not only difficult, but very generally unnecessary. The acidity, however, is often very high, and since they also contain fair percentages of clay, these soils would be expected to give results from liming. From experience it appears that many of them do benefit. With the exception of lime, however, and of occasional green manuring to *maintain* fertility, only those soils noticeably poorer than the average in some particular respect should require manuring at present.

Unlike the Daina-Toorsa district, which Mangaldai resembles in many respects, Malgaldai does not show any examples of alka-

line soil. In column 2 of the Table, however, is the analyses of a patch of soil very slightly acid only. It resembles the alkaline soils in many respects. The lime both total and available is high. The phosphoric acid is very high, the available phosphoric acid particularly high for a soil of such small acidity. The Grandeau organic matter is very low, although the loss on ignition and total nitrogen are normally high. These are signs of a recent deposit by a stream from the hills ; and the probability is that this represents a deposit newer than the average surrounding soil, but longer subjected to wash than soils still actually alkaline.

No. 3 is an example of the sandy type of soil commonly found. Even this is fairly evenly graded and differs only in degree from the average soil. This sandy type, however, more commonly overlies closely a very coarse sand when it may show drought effects more than the average soil. The particular example quoted has a relatively low acidity but is not typical in this respect.

No. 4 is commoner just under the hills in the North, but a few patches of it occur farther south, when it often overlies stones.

Even this is not a bad soil, when deep enough. With 22% of fine silt, and 8% clay, it will not suffer in an average dry season. Being sandy, it naturally has smaller percentages of nitrogen, etc.; but it is still quite well provided chemically, though it will probably give good results from additions of nitrogen. The Grandeau organic matter however is too low, and this soil needs green manure, cattle manure, or any form of organic matter.

No. 5 is an example of the old red soil of the foothills. It is physically unlike the commoner red bank types of the Dooars but like them is rich in organic matter and nitrogen. The available phosphoric acid is low, and it is probable that this soil would benefit from phosphatic manures particularly to assist the growth of the necessary green manures. Added organic matter will greatly improve the physical condition of the soil. Lime also will probably assist, both directly in flocculating clay, and indirectly in assisting the growth of good green crops.

The Lower Mangaldai Bed.

The gardens of this part of Mangaldai have not been visited by officers of the Scientific Department for a very long time.

For this reason the following extract from Dr. Mann's "Tea Soils of North East India" is quoted :—

"Of a totally different character is the soil which is met "with on the tea gardens which lie near the river. Here one "gets land very slightly above the level of the adjoining country, "and composed of a soil much finer in texture than those I have "just been describing. Furthermore it is not very deep, and at "a depth varying from eight to fifteen feet there is found, in "places at any rate, a subsoil water charged with sulphuretted "hydrogen, which is a plant poison, the ultimate depth of root "development is limited by the highest point to which this water "rises, and so on this land drains are a necessity, and should be "narrow, and in a hot district like Mangaldai banked up at the "sides. Owing to the lack of depth of the soils, exhaustion is apt "to quickly take place, but with manure, luxuriant bushes can, I "am confident, be kept up."

A number of analyses of gardens from this part have however been made, within the last few years. The following physical types occur :—

Kopati	... 2,3,4,5,1 (2 examples);	3,2,4,5,1; 3,4,2,5,1
Ronthali	... 2,4,3,5,1 (3 ,,);	2,3,4,5,1
Tokankatta	... 2,4,3,5,1 ; 3,2,4,5,1	
Bongaon	... 2,3,4,5,1 ; 4,3,2,5,1	
Kalaigaon	... 2,4,3,1,5 ;	2,1,4,3,5

All of these except one of the samples from Kalaigaon are "silt-loam" types, which are the commonest types in Upper Mangaldai.

Except at Kalaigaon, the two samples from which are very much more sandy than the average, coarse sand is always present in very small proportion, and is often practically absent altogether. Clay is always very low, no sample being found with more than 13% clay, while the average is about 8%.

Although containing less coarse sand, fine sand is high, while clay is present in less quantity than in the average Upper Mangaldai soil.

Mann's remark on the closer texture of the Lower Mangaldai soils, as compared to Upper Mangaldai, therefore needs explanation. The explanation undoubtedly lies in the very great difference in organic matter. Upper Mangaldai averages 6·5% loss on ignition and 2·2% soluble humus. Lower Mangaldai averages 3·4% loss on ignition and 1·0% soluble humus. The high organic matter keeps Upper Mangaldai soils open, while Lower Mangaldai soils of deficient organic matter, pack tightly, particularly when under the influence of deficient drainage. Leaving out the very sandy example from Kalaigaon the composition of the other examples is again constant enough for an average to mean something. The figures in column 6 are the averages from thirteen samples.

The much greater chemical poverty of Lower Mangaldai becomes clear when the figures in columns 1 and 6 are compared.

Lower Mangladai soils require all the organic matter they can get, and will usually give results from nitrogenous manures. There are great variations in available phosphoric acid (between less than ·01% up to ·09%), and smaller but still significant variations in available potash (·004% to ·018%). Some of these soils should give results from phosphatic and potassic manures.

Having little clay and, generally, low acidity, lime should not be required except in a few cases.

Physically the soils are not far from the ideal for tea, except in cases where fine silt is very high, and clay also present in significant quantity.

Given efficient drainage and reasonable manuring there is no reason why first class tea should not be grown in Lower Malgaldai.

Typical Analyses of Mangaldai.

	1. Average good loam of Upper Bed.	2. Example of new deposit Upper Bed from Orangajuli.	3. Example of sandy type from Attareekhat.	4. Example of coarse sand from Khoonder bheel.	5. Example of old red soil from Kerkeria.	6. Average silt loam of lower Mangaldai bed.
PHYSICAL TYPE	2, 3, 4, 5, 1	2, 4, 3, 5, 1	2, 1, 3, 5, 4	2, 1, 4, 3, 5	4, 5, 3, 1, 2	2, 3, 4, 5, 1
Mechanical Analysis—	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1. Coarse Sand	10	4·5	19	24	11	3
2. Fine Sand	28	29	38	29	10	36
3. Silt	22	21	17	13	15	25
4. Fine Silt	19	26	10	22	39	24
5. Clay	15	14	11	8	16	8
Loss on ignition (total combustible matter) ...	6·5	5·4	4·5	4·0	8·0	3·4
Chemical Analysis—						
Grandeau organic matter (soluble humus) ...	2·2	0·5	1·7	0·9	2·0	1·0
Acidity (pts. lime per million) (Veitch Albert)*	2,000	320	900	2,250	2,040	1,400
Insoluble silicious matter	85	82	88	86	73	87
Total Nitrogen	0·14	0·12	·107	·88	·159	·09
„ phosphoric acid	0·10	0·33	·095	·11	·124	·10
Available „ „	0·03	0·08	·037	·013	·006	·03
Total potash	0·25	0·57	.. ..	.....	....	.....
Available potash	0·02	0·03	·024	·013	·011	·009
Total lime	0·2	0·79	.....	.....	.....	.....
Available lime	0·1	0·48	·130	·07	·03	·06
Total magnesia	0·5	0·85	.....	.....	.....	.....
Available magnesia	0·07	0·10	·066	·06	·05	·05

* Lyon and Bizzel modification.